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Curricular activities and change in determinants of fruit and vegetable intake among adolescents: Results from the Boost intervention

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ABSTRACT

Knowledge of the association between implementation of different intervention components and the determinants they are tailored to change may contribute to evaluating the effects and working mechanisms of multi-component interventions. This study examined 1) the effect of a Danish multi-component school-based intervention (2010–2011) on key determinants of adolescents' fruit and vegetable intake and 2) if dose of curricular activities was positively associated with change in these determinants. Using multi-level linear and logistic regression analyses stratified by gender and socioeconomic position, we analyzed survey data from the cluster-randomized Boost study targeting Danish 13-year-olds' fruit and vegetable intake. We examined 1) differences in knowledge of recommendations, taste preferences and situational norms between students from 20 intervention ($n = 991$) and 20 control ($n = 915$) schools at follow-up; and 2) associations between curriculum dose received and delivered (student and teacher data aggregated to school- and class-level) and these determinants among students at intervention schools only. At follow-up, more students from intervention than control schools knew the recommendation for vegetable intake (OR 1.56, CI: 1.18, 2.06) and number of fruits liked (taste preferences) increased by 0.22 (CI: 0.04, 0.41). At class-level, curriculum dose received was positively associated with proportion of students knowing the recommendation for vegetable intake (OR 1.06, CI: 1.002, 1.13). In stratified analyses, this association was only significant among students from high social class (OR 1.17, CI: 1.04, 1.31). The Boost intervention succeeded in improving students' taste preferences for fruit and knowledge of recommendation for vegetable intake, but only the latter determinant was positively associated with curriculum dose.

Trial registration: ISRCTN11666034

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1. Introduction

Many schoolchildren do not reach the international recommendation of eating at least 400 g of fruit and vegetables (FV) daily (Currie et al., 2012; Pedersen et al., 2015). School-based multi-component interventions combining educational and environmental strategies have been shown to be effective in increasing children's FV intake (Evans et al., 2012; Knai et al., 2006; Van Cauwenberghe et al., 2010; Wang & Stewart, 2012). However, several studies report poor implementation (Christian et al., 2012; Lytle et al., 2004; Reinaerts et al., 2007; Wind et al., 2008), for example low implementation level of curricular

components delivered by teachers (Christian et al., 2012; Wind et al., 2008). To enable correct interpretation of intervention effects and develop effective intervention components, knowledge of the implementation of separate intervention components is important (Linnan and Steckler, 2002). Furthermore, assessment of the implementation may clarify whether lack of change in important determinants of FV intake is caused by low implementation of the components addressing these determinants or by lack of effect of the chosen intervention tools (Linnan and Steckler, 2002; Durlak and DuPre, 2008).

Curricular components in previous multi-component dietary interventions among children and adolescents (Wind et al., 2008; Bere et al., 2006; Lehto et al., 2014; Story et al., 2000; Anderson et al., 2005; Bessems et al., 2013) have targeted determinants such as taste preferences, dietary knowledge, awareness of national recommendations for FV intake, and practical skills. Two of these studies (Bere et al., 2006; Lehto et al., 2014; Story et al., 2000; Anderson et al., 2005) examined the impact of the entire intervention on changes in determinants of FV intake. Anderson et al. (2005) found a greater increase in children's

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(6–7 and 10–11 years old) knowledge and subjective norms (perceived social pressure from school nurse) in the intervention group compared to the control group, while taste preferences were unchanged. Bere et al. (2006) identified a significant difference between intervention and control groups for awareness of recommendations for FV intake, but not for home accessibility, modelling, intention to eat five-a-day, preferences and self-efficacy to eat five-a-day. We have not been able to identify multi-component intervention studies examining the association between implementation level of curricular components separately and change in determinants of FV intake among adolescents.

The aim of this study was therefore to evaluate if a curricular component worked through its intended theory- and evidence-based link (Baranowski and Jago, 2005; Aarestrup et al., 2014a; Cerin et al., 2009) by 1) examining the effect of the entire multi-component intervention on *three important determinants of adolescents' FV intake* addressed by the curricular component: *knowledge of recommendations, taste preferences and situational norms related to FV intake* (Krølner et al., 2011; Rasmussen et al., 2006; Sleddens et al., 2015). These determinants were identified in reviews of quantitative and qualitative studies of children's and adolescents' FV intake (Krølner et al., 2011; Rasmussen et al., 2006); and 2) examining if implementation level of this curricular component (dose delivered and received) was associated with change in these three determinants. The study has been pre-specified as a secondary analysis of Boost intervention data in the trial registry Current Controlled Trials ISRCTN11666034 (<http://www.isrctn.com/ISRCTN11666034>).

2. Methods

2.1. The Boost intervention

The Boost intervention aimed to increase adolescents' FV intake through curricular activities and free FV distribution at school, parental newsletters and fact sheets for sports- and youth clubs (Krølner et al., 2012). Development of the intervention was guided by the Intervention Mapping protocol (Krølner et al., 2012; Bartholomew et al., 2006).

The Boost intervention lasted nine months (September 2010–May 2011). It was tested in a school-randomized controlled trial among all seventh grade students (\approx 13-year-olds) from a random sample of 20 intervention and 20 control schools from 10 randomly selected municipalities in Denmark. Implementation of intervention components was monitored by a thorough quantitative and qualitative process evaluation (Aarestrup et al., 2014a; Jørgensen et al., 2014; Aarestrup et al., 2014b; Aarestrup et al., 2015). The Boost intervention is described in details elsewhere (Krølner et al., 2012).

2.2. The Boost curriculum

As specified in the Boost program theory, each intervention component was designed to change adolescents' FV intake (distal outcome) through changes in specific determinants of FV intake (proximal outcomes) (Krølner et al., 2012). Curricular activities specifically aimed at changing assessment of personal FV intake, FV intake in the class and family and personal goal setting (awareness, situational and social norms); analysis and production of food related advertisements (influence from media); study of how FV intake affects the body (short term outcome expectations); tasting different types of FV (taste preferences); cookery at school (skills and taste preferences), and discussing occasions and meals appropriate for eating FV (situational and social norms, influence from peers and family); field trips to local supermarkets or fruit orchards (awareness of availability) (Krølner et al., 2011; Rasmussen et al., 2006; Krølner et al., 2012). This study focuses on two known important determinants of adolescents' FV intake (Krølner et al., 2011; Rasmussen et al., 2006): Knowledge of recommendations and taste preferences, and on one potential determinant for adolescents' FV intake (Krølner et al., 2011): Situational norms related to FV intake

(perceived appropriate occasions and time for eating FV). Students' perceptions of whether it is appropriate to eat FV in school or at birthdays may influence their intake during these occasions.

The Boost curriculum was based on existing material from other interventions (Klepp et al., 2005; Lien et al., 2010) and consisted of four parts: 1) A detailed teacher manual including 12 compulsory, five optional, and eight additional activities, each to be carried out during 1–4 class lessons. A time schedule specified 1–3 activities which were to be implemented monthly to ensure regular exposure; 2) A teacher script for a project week (four compulsory and four optional activities); 3) A student workbook covering the activities presented in the teacher manuals; 4) A computer tailoring module tailored to students' FV intake, awareness level, taste preferences, and leisure time activities which students were expected to complete three times (Krølner et al., 2012).

The activities were designed to be integrated in different school subjects for example maths, home economics and physical education, and to comply with national learning objectives for these (Krølner et al., 2012). Teachers were to implement all compulsory activities in each of the seventh grade classes but were allowed adaptations to their local context. The teaching material is available in Danish (www.cirhp.dk).

2.3. Fruit and vegetable distribution and parental newsletters

Teachers were responsible for daily distribution of one free piece of fruit or vegetable to every student. To create a pleasant eating environment, teachers were encouraged to implement a FV break and to cut up the FV in appealing snacks. Boost coordinators at the schools were asked to post six Boost parental newsletters at the school's website for parents with ideas on how to increase adolescents' FV intake at home and in their leisure time.

2.4. Study sample and data collection

In this study, we combined data from students, teachers, parents and principals. Before intervention start (August 2010), 1121 students at intervention schools completed a baseline questionnaire (response rate of enrolled students: 95.4%). Of these, 991 students (84.3%) completed a follow-up questionnaire post intervention (May/June 2011). At control schools, 1035 students (response rate of enrolled students: 92.9%) completed the baseline questionnaire. Of these, 915 students (82.1%) completed the follow-up questionnaire.

Students completed web-based questionnaires during school hours and received paper questionnaires for their parents to complete. At intervention schools, parent data were received for 655 students (58.4% (655/1121)) at baseline and 368 students (37.1% (368/991)) at follow-up.

Web-based questionnaires were sent to principals and teachers by email. All principals ($n = 20$, 100%) completed baseline and follow-up surveys (October 2010 and July 2011). We received teacher data from all intervention schools post intervention. Number of seventh grade teachers involved in implementation of the curriculum at each intervention school differed from two to all (total number of teachers at seventh grade ranged from six to 21).

The Boost study adheres to all Danish ethical standards and the Declaration of Helsinki and is approved by the Danish Data Protection Agency (J.nr. 2010–54-0974). Parents could indicate in their questionnaire whether they wanted the project group to exclude their child's questionnaire from the database. Responses were treated anonymously and confidentially.

2.5. Measures

Table 1 summarizes study measures. Dependent variables: Determinants of FV intake (student data): 1) Correct knowledge of recommendations for FV intake. In Denmark, children > 10 years are recommended

Table 1

Description of outcome measures, determinants and covariates (Danish multi-component intervention, 2010–2011).

Measure	Respondents (time of assessment)	Survey question	Response categories/codes in the questionnaire	Range of continuous variables and categories of categorical variables included in analysis
Dependent variables				
Knowledge of national recommendations for fruit and vegetable intake, respectively	Students (follow-up)	“How much fruit do you think you should eat to have a healthy diet?” Same question for vegetables (portions per day/week).	a. No fruit b. 1–3 pieces of fruit per week c. 4–6 pieces of fruit per week d. 1 piece of fruit every day e. 2 pieces of fruit every day f. 3 pieces of fruit every day g. 4 pieces of fruit every day h. 5 pieces of fruit every day i. 6 or more pieces of fruit every day	≤2 pieces: a, b, c, d, e (reference group) >2 pieces: f, g, h, i
Taste preferences for fruit and vegetables, respectively	Students (follow-up)	“Which of the following fruits do you like or dislike?” 15 different fruits/group of fruits were listed. “Which of the following vegetables (raw or cooked) do you like or dislike?” 20 different vegetables/group of vegetables were listed. Potatoes excluded. Students were asked to rate how much they liked each fruit/vegetable listed. Each fruit/vegetable rated by the student counted as one fruit/vegetable the students liked. We added up the number of fruits/vegetables each student liked.	a. Really like it b. Like it okay c. Don't like it so much d. Don't like it e. Haven't tasted it Like it: a, b Don't like it: c, d, e	Fruit: 0–15 types Vegetables: 0–20 types
Situational norms for occasions suitable for fruit and vegetables, respectively	Students (follow-up)	“Which of the following occasions do you find fruit suitable for?” Same question for vegetables.	Birthdays Sport (e.g. training, competitions, matches) Parties Watching TV In the movie theatre Being with friends Being with family At a restaurant In school Other events None of the above events	Fruits: 0–9 occasions Vegetables: 0–9 occasions
Independent variables				
Dose received of Boost curriculum	Students (follow-up)	Students were asked to rate how much they liked each of the Boost curricular activities they had been exposed to during the intervention period. Each activity rated by the student counted as one activity received by the student. We added up the activities received by each student and calculated the class- and school-average.	Short description of each Boost curricular activity	School-level dose: average number of Boost curricular activities received by students at each school 3.6–12.3 (school mean) Class-level dose: average number of Boost curricular activities received by students in each class 0–13.5 (class mean)
Dose delivered of Boost curriculum	Teachers (follow-up)	“Which of the Boost curricular activities from the teacher manual mentioned below did you teach during the Boost intervention period September 2010–May 2011?” A similar question was asked for activities from the script for a Boost project week.	List of all Boost curricular activities to tick off (listed by number and name consistent with teacher manuals)	School-level dose: average number of Boost curricular activities delivered by teachers at each school Low (0–3.8) (reference group) Medium (3.9–6.7) High (≥6.8)
Covariates				
<i>Baseline level of dependent variables</i>				
Knowledge of recommendations	Students (baseline)	(see outcome measure)		
Taste preferences	Students (baseline)	(see outcome measure)		
Situational norms	Students (baseline)	(see outcome measure)		
<i>Prior “treatment” at schools</i>				
The school's focus on FV prior to participation in the Boost intervention	Principals (baseline)	“Did your school prior to the Boost project focus on FV for example as part of project weeks or school projects?”	Yes No	Yes No (reference group)
FV availability at school apart from the FV delivered as part of the Boost intervention	Principals (baseline)	“Is it possible for students at seventh grade to buy the following at the school?: 1) Fruit 2) Vegetables/salad”	Yes, every day Yes, most days Some days Never	Everyday Most days or less (reference group)
<i>Dose delivered of other intervention components</i>				
Dose delivered of parental Boost newsletters	Teachers (only Boost coordinators)	“During the school year, Boost emailed six parental newsletters for the Boost coordinators to post on the schools' website for parents. How many of these were	0 newsletters 1 newsletter 2 newsletters	School-level dose: number of posted newsletters at each school 0–3 newsletters (reference group)

Table 1 (continued)

Measure	Respondents (time of assessment)	Survey question	Response categories/codes in the questionnaire	Range of continuous variables and categories of categorical variables included in analysis
	(follow-up)	posted?"	3 newsletters 4 newsletters 5 newsletters 6 newsletters	4–6 newsletters
Dose delivered of the pleasant eating environment component	Teachers (follow-up)	"How often do you cut up FV when students eat FV during your lessons?"	Every time Most times Some times Seldom Never	School-level dose: proportion of teachers at each school cutting up FV every time/most times students eat FV in class ≤50% (reference group) >50%
<i>Sociodemographic factors</i>				
Gender	Students (baseline)	"Are you a boy or a girl?"	Boy Girl	Boy Girl (reference group)
Family occupational social class	Students (baseline)	"Mother's/father's job title" (written answer) "Mother's/father's workplace" (written answer) Based on job title and place of work of the mother and father, each parent was coded into one of five occupation social classes or some additional groups using standardized coding principles. Family occupational social class was based on the highest ranking parent. Students who did not provide sufficient information to code parents into occupational social classes or additional groups were excluded.	I High II III IV V Low VII Social Welfare benefits	High: I, II, III Low: IV, V, VII (reference group)
Family educational level	Parents (baseline)	"Which school education do you have?" "Which vocational education do you have?" (If you have more than one, please tick off the highest level of education) Based on completed education, mothers and fathers were categorized into one of five educational categories using national coding principles. Family educational level was based on the highest ranking parent. Unclassifiable parents were excluded.	a. Enrolled in education b. Primary school c. Manual education d. Low theoretical education e. Medium high theoretical education f. High theoretical education	High education: e–f Low education: a–d (reference group)

to eat at least 600 g (2.5 cups) of FV daily, including at least 300 g of vegetables (Pedersen et al., 2015). Thereby, correct knowledge of recommendations was defined as >2 pieces of fruit and >2 pieces/portions of vegetables (1 piece/portion = counts as 100 g). 2) Taste preferences measured by number of specified FV liked by the student. 3) Situational norms for eating FV measured by number of occasions the student found FV suitable for (e.g. birthdays, being with friends).

Independent variables: Curriculum dose received at school- and class-level: average number of activities received by students at each school and in each class, respectively (student data). Curriculum dose delivered (teacher data) at school-level: average number of activities (compulsory, optional and additional) delivered at each school during the intervention (low: 0–3.8, medium: 3.9–6.7, high: ≥6.8 dose delivered). In the questionnaire, teachers could tick of a box called 'Additional activities' if they had implemented any of the eight additional activities. It was therefore not possible for them to specify the number of additional activities implemented. Thus, in the estimation of the final dose delivered at school-level additional activities counted as one activity independent of the number of additional activities implemented. We measured both dose received and dose delivered to get detailed information on the implementation level and its effect on distal and proximal outcomes (Aarestrup et al., 2014a).

Covariates: Baseline level of outcome variables (student data): 1) Students' knowledge of recommendations, taste preferences and situational norms; Prior 'treatment' (principal data): 2) Schools' focus on FV prior to intervention start; 3) Students' access to FV in school besides free Boost FV. We controlled for dose delivered of other intervention components (teacher data) to isolate the effect of curricular activities on students' knowledge of recommendations, taste preferences, and situational norms; 4) Number of parental newsletters delivered by Boost coordinators. At six schools, teacher data on number of newsletters uploaded were missing and substituted by parent data on number of newsletters received; 5) Dose delivered of a pleasant eating

environment measured by how often the FV were cut up in appealing snacks; Sociodemographic factors (student and parent data): 6) Gender; 7) Students' information on mother's and father's job title and workplace was coded into parental occupational social classes based on standardized coding principles (Christensen et al., 2014; Krølner and Johansen, 2007). We used student data on occupational social class instead of parent data due to low response rate among parents; 8) Parent-reported educational background was coded into educational levels according to national coding principles (Statistics Denmark and The Ministry of Education, 2006). Family occupational social class and family educational level were determined by highest ranking parent.

2.6. Analytical model and statistical analyses

We analyzed differences in students' knowledge of recommendations, taste preferences and situational norms between intervention and control schools at follow-up, using multi-level analyses adjusted for baseline level of outcome measures. We examined the association between curriculum dose and knowledge of recommendations, taste preferences and situational norms at follow-up at intervention schools using multi-level analyses adjusted for baseline level of outcome measures, prior 'treatment' and dose delivered of other intervention components. Control schools were excluded from this analysis as they did not receive any of the intervention components.

We conducted logistic regression analyses of the dichotomous outcome (knowledge of recommendations) and analysis of variance of continuous outcomes (taste preferences; situational norms). The hierarchical data structure was accounted for by including school-, class- and student-level as random effects in the analyses. It was not possible to estimate the three random effects in all models.

Potential moderation of the associations between dose received at class-level and outcomes were examined by 1) including interaction terms between dose and gender, dose and family occupational social

class, and dose and family educational level in three separate analyses and 2) stratifying analyses by the potential moderators. Only 53.1% (595/1121) of the students were included in the analyses based on parent-reported educational level.

We only examined potential moderations for dose received at class-level (student data) as we believe this is the most valid measure of curriculum dose.

In sensitivity analyses, we examined the implications of different cut-points for categorizing curriculum dose delivered, occupational social class and educational level. In attrition analyses, we tested for differences in baseline measures between students from intervention and control schools, with and without a follow-up assessment using chi-square test (dichotomous outcome) and *t*-test (continuous outcomes).

We found a weak collinearity between dose delivered of other intervention components and curriculum dose (Spearman's correlation coefficients <0.40). We tested for linearity between curriculum dose and the baseline as well as follow-up measures of the continuous outcomes (taste preferences and situational norms), and by 1) visual inspection of scatter plots, 2) creating various categorical variables to test if an upward or downward curve of the parameter estimates existed, and 3) squared term included in the model.

Model assumptions for continuous outcomes were evaluated using visual inspection of residual plots and QQ-plots, and Kolmogorov-Smirnov test for normality. Taste preferences for fruit at follow-up had a skewed distribution, but various transformations including square root and rank-transformation did not normalize it. Rank-transformation showed similar trends in *P*-values and estimates as seen in the non-transformed analysis. We conducted analyses of non-transformed outcome measures using the statistical software package SAS version 9.3 and chose *a priori* a 5% significance level. Missing data were excluded.

3. Results

The average curriculum dose received (across students in a school) ranged from 3.5 (two schools) activities during the intervention period to 11.4 (one school). The average dose delivered (across teachers in a school) ranged from zero (two schools) activities to 10.7 (one school). The highest average dose received and delivered, respectively, were seen at two different schools. Low, medium and high curriculum doses were delivered to students at seven, six and seven schools, respectively. The majority of schools (70%) had focused on FV prior to the intervention and had FV available for purchase (65%). In 11 schools, teachers had uploaded at least four of the six parental newsletters. In 10 schools, >50% of the teachers cut up FV every time or most times they distributed FV in their classes (Table 2).

In unadjusted multi-level models of dose received, the between-class variation in dose received was larger than the between-school variation (Intraclass Correlations (ICC) = 14% versus 6%).

3.1. Intervention effects on determinants of fruit and vegetable intake at follow-up

At follow-up, more students at intervention schools knew the correct national recommendation for vegetable intake compared to control schools (OR 1.56 CI: 1.18, 2.06) and students at intervention schools liked 0.22 more types of fruit (CI: 0.04, 0.41) compared to students at control schools. No differences were observed for knowledge of recommendation for fruit intake, taste preferences for vegetable intake or situational norms related to eating FV (Table 3).

3.2. Curriculum dose received and change in determinants of fruit and vegetable intake

At school-level, curriculum dose received was not significantly associated with any of the outcome measures. At class level, curriculum dose received was significantly associated with an increase in students'

Table 2

Distribution of included variables (Danish multi-component intervention, 2010–2011).

Modifiers (data source)	Intervention schools, <i>n</i> _{students} (%)	Missing (%)	Control schools, <i>n</i> _{students} (%)	Missing (%)
<i>Gender (student)</i>		0		0
Girls	498 (49.3)		443 (48.4)	
Boys	502 (50.7)		472 (51.6)	
<i>Occupational social class (student)</i>		287 (30)		264 (28.9)
High	346 (41.5)		318 (41.3)	
Low	488 (58.5)		453 (58.8)	
<i>Educational level (parent)</i>		466 (47)		491 (53.7)
High	364 (55.6)		313 (57.5)	
Low	291 (44.4)		231 (42.5)	
Independent variables (data source)		Intervention schools		
		<i>n</i>_{students}(%) or <i>n</i>_{schools}(%)		
<i>Curriculum dose delivered at school-level (teacher)</i>				
Low		376 (37.9)		
Medium		257 (25.9)		
High		358 (36.1)		
<i>Curriculum dose received at school-level (student)</i>		Mean 7.1 (range: 3.5–11.4)		
<i>Curriculum dose received at class-level (student)</i>		Mean 7.1 (range: 0–13.5)		
<i>School's focus on FV prior to the Boost intervention (school principal)</i>				
Yes		646 (65.2)		
No		345 (34.8)		
<i>FV availability at school apart from the Boost distribution (school principal)</i>				
Every day		707 (71.3)		
Most days or less		284 (28.7)		
<i>Newsletters: dose delivered at school-level (teacher)</i>				
2–3		439 (44.3)		
4–6		552 (55.7)		
<i>Pleasant eating environment: dose delivered at school-level (teacher)</i>				
≤50%		457 (46.1)		
>50%		534 (53.9)		

knowledge of recommendation for vegetable intake (OR 1.06, CI: 1.002, 1.13) (Table 4). Analyses with interaction terms showed that this association was moderated by occupational social class (*P* = 0.04) (interaction terms not shown). In stratified analyses, the association was only significant among students of high occupational social class (OR 1.17, CI: 1.04, 1.31) and boys (OR 1.09, CI: 1.004, 1.18) but not among students of low occupational social class (OR 1.01, CI: 0.93, 1.10) and girls (OR 1.02, CI: 0.93, 1.12). Curriculum dose received at class-level was not significantly associated with change in knowledge of recommendation for fruit intake, taste preferences or situational norms.

At school level, teacher-reported curriculum dose delivered was not associated with change in knowledge of recommendations, taste preferences or situational norms (Table 5).

All findings were robust to changes in cut-points for curriculum dose, occupational social class and educational level.

3.3. Attrition analysis

Compared to students with follow-up assessments at intervention schools, students without follow-up assessments (*n* 130) were more likely to be boys (60.8% versus 50.7%, *P* = 0.03) and live in families of low occupational social class (65.9% versus 57.9%, *P* = 0.02) and less likely to know the national recommendation for vegetable intake at baseline (38.8% versus 48.1%, *P* = 0.05) and found fewer occasions appropriate for eating fruit (3 versus 4 occasions (median), *P* = 0.04)

Table 3

Distribution of outcome variables and differences in knowledge of recommendations, taste preferences and situational norms related to FV between intervention and control schools in the Danish Boost study (2010–2011) (*n* 1906).

Dependent variables	Baseline				Follow-up				Difference between intervention and control schools at follow-up		
	Intervention schools, <i>n</i> _{students} (%) or mean/median (range)	Missing <i>n</i> _{students} (%)	Control schools, <i>n</i> _{students} (%) or mean/median (range)	Missing <i>n</i> _{students} (%)	Intervention schools, <i>n</i> _{students} (%) or mean/median (range)	Missing	Control schools, <i>n</i> _{students} (%) or mean/median (range)	Missing <i>n</i> _{students} (%)			
Knowledge of recommendations									OR^a	CI95%	P
Fruit		5 (0.01)		1 (0.001)		1 (0.001)		1 (0.001)	1.27	0.88, 1.83	0.19
<2 pieces	219 (22.2)		212 (23.2)		154 (46.8)		175 (53.2)				
≥2 pieces	767 (77.8)		702 (76.8)		836 (53.1)		739 (46.9)				
Vegetables		5 (0.01)		2 (0.002)		1 (0.001)		2 (0.002)	1.56	1.18, 2.06	0.003
<2 pieces	512 (51.9)		475 (52.0)		345 (45.9)		407 (54.1)				
≥2 pieces	474 (48.1)		438 (48.0)		645 (56.0)		506 (44.0)				
Taste preferences									Estimate^b	CI95%	P
Fruit (0–15)	12.00/13	5 (0.01)	11.85/13	2 (0.002)	12.13/13	1 (0.001)	11.80/13	1 (0.001)	0.22	0.04, 0.41	0.02
Vegetables (0–20)	10.79/11	5 (0.01)	10.87/11	2 (0.002)	10.91/11	2 (0.002)	11.23/11	2 (0.002)	−0.26	−0.65, 0.14	0.21
Situational norms											
Fruit (0–9)	3.77/4	10 (0.01)	3.76/4	8 (0.01)	3.99/4	10 (0.01)	3.92/4	3 (0.003)	0.05	−0.15, 0.25	0.62
Vegetables (0–9)	3.03/3	43 (0.04)	3.10/3	27 (0.03)	3.26/3	35 (0.04)	3.12/3	22 (0.02)	0.15	−0.11, 0.40	0.27

^a Logistic regression analysis.

^b Analysis of variance.

and vegetables (2 versus 3 occasions (median), $P = 0.001$) (situational norms).

At control schools, students without follow-up assessments (*n* 120) were less likely to know the national recommendation for fruit intake (62.5% versus 76.8%, $P = 0.001$) and found fewer occasions appropriate for eating fruit (3 versus 4 occasions (median), $P = 0.002$) and vegetables (2 versus 3 occasions (median), $P = 0.01$) (situational norms) compared to students with follow-up assessments. No differences were seen for gender, social class and educational level.

4. Discussion

The Boost intervention was effective in changing students' knowledge of recommendation for vegetable intake. Curriculum dose received at the class-level was positively associated with changes in this determinant. In stratified analyses, the association was only significant among students of high occupational social class. The Boost intervention was also effective in improving students' taste preferences towards fruit at follow-up. At school level, curriculum dose was not associated with any of the determinants investigated.

Similar to our study, two multi-component studies (Bere et al., 2006; Anderson et al., 2005) were effective in changing students' knowledge related to FV at nine months' follow-up, while none of the studies were effective in changing taste preferences. The two studies included younger students (<12 years old), determinants were not measured separately for FV and measurements of determinants differed from our measurements.

No previous studies have examined the association between curriculum dose and changes in determinants of FV intake among adolescents. The intervention dose of an entire multi-component intervention (FV snacks, FV events and parental letters) was associated with 10–11-year-olds' knowledge of recommendations for FV intake and taste preferences for fruit (Lehto et al., 2014).

The observed effectiveness of the Boost intervention in changing knowledge of recommendation for vegetable intake and taste preferences for fruit might be a result of the intended synergistic effect among simultaneously implemented intervention components (Krølner et al., 2012). Our study did not explore this potential synergy as our analyses of the curricular component were adjusted for the implementation of other components. Still, our findings indicate that the

curricular component contributed to the improved level of knowledge of recommendation for vegetable intake, and that the number of activities received by students matters for the size of this change. For every extra activity received, students were 6% more likely to know the national recommendation (OR 1.06). Number of activities received by students in each class did not seem to explain the intervention effect on taste preferences for fruit. Future analyses should examine if this effect can be explained by the free daily provision of FV at class. The role of curriculum dose on actual FV intake self-reported by students has been shown (Jørgensen et al., 2015).

Previous interventions have not succeeded in changing vegetable intake among children and adolescents (Evans et al., 2012; Van Cauwenberghe et al., 2010; Lehto et al., 2014). This study indicates that curricular activities may be one successful strategy for changing determinants of adolescents' vegetable intake. Curriculum dose seemed to be associated with knowledge of recommendation for vegetable intake among students of high occupational social class only. These students may be more receptive to change their knowledge of recommendation for vegetable intake as they are likely to experience more parental support in making healthy choices (Yildirim et al., 2011). However, results from stratified analyses should be interpreted with caution due to small sample sizes and multiple test issues.

Curriculum dose at school-level may be too crude as it ignores the fact that dose received and delivered may differ by classes within the same school (Baranowski and Jago, 2005; Jørgensen et al., 2014). The importance of measuring intervention dose at the class-level was supported by the greater between-class than between-school variation in curriculum dose received. Also, when estimating dose delivered, additional activities counted as one activity independent of the number of additional activities implemented. Unfortunately, data on the exact number of additional activities were not collected. This way of measuring additional activities might have implications for the classification of schools into low, medium or high dose. Potentially, some schools may have been misclassified with a lower number of activities than were actually implemented. For thorough discussions of methodological issues related to curriculum dose in the Boost intervention, see Jørgensen et al. (2015). It may be difficult for students to remember activities implemented in the beginning of the intervention period when asked at the end. To prevent recall bias students were presented with a short description of each activity. The same approach was applied in the teacher

Table 4
Association between student-reported curriculum dose received at class-level and students' knowledge of recommendations, taste preferences, and situational norms related to FV intake at follow-up (*n* 991) (Danish multi-component intervention, 2010–2011).

Analysis of all students	Variable	Adjusted model ^{c,d}	
		OR ^a	CI95%
	Knowledge of recommendation, fruit	0.99	0.92, 1.07
	Knowledge of recommendation, vegetables	1.06	1.002, 1.13
		Estimate^b	
	Taste preferences, fruit	0.02	−0.03, 0.07 (<i>P</i> = 0.48)
	Taste preferences, vegetables	0.06	−0.05, 0.17 (<i>P</i> = 0.26)
	Situational norms, fruit	0.02	−0.02, 0.07 (<i>P</i> = 0.36)
	Situational norms, vegetables	0.01	−0.05, 0.07 (<i>P</i> = 0.71)
Analysis stratified by gender	<i>Girls</i>	OR^a	
	Knowledge of recommendation, fruit	0.96	0.84, 1.09
	Knowledge of recommendation, vegetables	1.02	0.93, 1.12
		Estimate^b	
	Taste preferences, fruit	−0.02	−0.09, 0.04 (<i>P</i> = 0.53)
	Taste preferences, vegetables	−0.01	−0.14, 0.11 (<i>P</i> = 0.82)
	Situational norms, fruit	0.02	−0.04, 0.08 (<i>P</i> = 0.54)
	Situational norms, vegetables	−0.02	−0.10, 0.06 (<i>P</i> = 0.67)
	<i>Boys</i>	OR^a	
	Knowledge of recommendation, fruit	1.001	0.90, 1.12
	Knowledge of recommendation, vegetables	1.09	1.004, 1.18
		Estimate^b	
	Taste preferences, fruit	0.05	−0.03, 0.13 (<i>P</i> = 0.19)
	Taste preferences, vegetables	0.13	−0.02, 0.28 (<i>P</i> = 0.09)
	Situational norms, fruit	0.01	−0.05, 0.06 (<i>P</i> = 0.86)
	Situational norms, vegetables	0.02	−0.04, 0.08 (<i>P</i> = 0.49)
Analysis stratified by family occupational social class	<i>High family occupational social class</i>	OR^a	
	Knowledge of recommendation, fruit	1.07	0.92, 1.24
	Knowledge of recommendation, vegetables	1.17	1.04, 1.31
		Estimate^b	
	Taste preferences, fruit	0.01	−0.08, 0.10 (<i>P</i> = 0.80)
	Taste preferences, vegetables	−0.05	−0.22, 0.12 (<i>P</i> = 0.57)
	Situational norms, fruit	0.08	−0.05, 0.08 (<i>P</i> = 0.60)
	Situational norms, vegetables	0.05	−0.05, 0.15 (<i>P</i> = 0.36)
	<i>Low family occupational social class</i>	OR^a	
	Knowledge of recommendation, fruit	0.98	0.89, 1.08
	Knowledge of recommendation, vegetables	1.01	0.93, 1.10
		Estimate^b	
	Taste preferences, fruit	0.03	−0.05, 0.11 (<i>P</i> = 0.51)
	Taste preferences, vegetables	0.09	−0.06, 0.24 (<i>P</i> = 0.25)
	Situational norms, fruit	0.03	−0.04, 0.09 (<i>P</i> = 0.40)
	Situational norms, vegetables	−0.01	−0.09, 0.07 (<i>P</i> = 0.89)

^a Logistic regression analysis.

^b Analysis of variance.

^c Adjusted model: Models with curriculum dose and knowledge of recommendations, taste preferences and situational norms related to FV, respectively, adjusted for baseline level of knowledge of recommendations, taste preferences and situational norms related to FV, and dose delivered of other intervention components.

^d Significant associations in bold.

survey. Teachers may have over-reported implementation of the compulsory curriculum to please the research team (social desirability bias). In a qualitative study of barriers and facilitators for implementation of the Boost curriculum, teachers felt that their position as a chosen intervention school in a research project obliged them to implement the intervention (Jørgensen et al., 2014).

The measurement of situational norms has not previously been validated, which might explain the lack of association with curriculum dose.

Changing complex determinants such as taste preferences and situational norms may depend on quality of the curricular activities delivered rather than number of activities. We do not know if teachers implemented the curricular activities according to the teacher manual. Work overload, competing demands, preparation time and research fatigue (Knai et al., 2006; Jørgensen et al., 2014; Aarestrup et al., 2015; Clark, 2008; Naylor et al., 2015) may have lowered teachers' implementation of curricular activities scheduled to take place late in the school year.

Strengths of this study include the use of the multiple data sources and validated measurements of knowledge of recommendations and taste preferences (De Bourdeaudhuij et al., 2005), an explicit program theory, examination of the role of both curriculum dose received and delivered, and high response rates among students and principals. Also, this study focuses on FV separately which is needed as FV intake may be seen as two different behaviours (Dudley et al., 2015; Glasson et al., 2011).

5. Conclusions

The multi-component Boost intervention was effective in changing students' knowledge of recommendation for vegetable intake and taste preferences towards fruit. There was a dose-response relationship between curriculum dose received at class-level and students' knowledge of recommendation for vegetable intake. Future studies should explore ways to increase teachers' response rate in order to get more valid assessment of dose delivered. Exploring strategies for changing

Table 5

Association between teacher-reported curriculum dose delivered at school-level and students' knowledge of recommendations, taste preferences, and situational norms related to FV intake at follow-up (*n* 991) (Danish multi-component intervention, 2010–2011).

Variable	Adjusted model ^{c,d}		
	Estimate	OR	CI95%
Analysis of all students			
Knowledge of recommendation, fruit ^a	Ref.	.	.
Low dose	0.33	1.39	0.58, 3.35
Medium dose			
High dose	−0.11	0.90	0.42, 1.94
Knowledge of recommendation, vegetables ^a	Ref.	.	.
Low dose	0.29	1.34	0.68, 2.63
Medium dose			
High dose	0.12	1.13	0.61, 2.09
	Estimate	CI95%^d	P
Taste preferences, fruit ^b	Ref.	.	0.11
Low dose	0.39	−0.04, 0.83	
Medium dose			
High dose	0.46	0.06, 0.87	
Taste preferences, vegetables ^b	Ref.	.	
Low dose	0.60	−0.48, 1.68	0.53
Medium dose			
High dose	0.52	−0.47, 1.50	
Situational norms, fruit ^b	Ref.	.	
Low dose	−0.14	−0.63, 0.34	0.55
Medium dose			
High dose	0.08	−0.37, 0.52	
Situational norms, vegetables ^b	Ref.	.	0.70
Low dose	0.25	−0.43, 0.93	
Medium dose			
High dose	0.26	−0.36, 0.88	

^a Logistic regression analysis.

^b Analysis of variance.

^c Adjusted model: Models with curriculum dose and knowledge of recommendations, taste preferences and situational norms related to FV, respectively, baseline level of the three outcomes and dose delivered of other intervention components.

^d Significant associations in bold.

determinants of FV intake among boys and adolescents of low SEP are particularly important as these subgroups generally have low FV intake. It is important not to increase social inequities through whole of setting approaches. Such knowledge will be useful for planning future school-based curricular interventions in order to implement the most effective types of activities and to identify the minimum curriculum dose required to promote behavioral change.

Conflict of interests

None.

Authors' contributions

TSJ, MR, RK and PD conceived the study and designed the analytical strategy. TSJ conducted the data analyses and drafted the manuscript. MR, RK, PD and SEJ contributed to the interpretation of data. AKE and SEJ provided statistical advice. TSJ, RKR, AKA, PD developed the Boost study and participated in data collection. RK is principal investigator of the Boost study. All authors revised the manuscript critically and have read and approved the final manuscript.

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